(12) UK Patent Application (19) GB (11) 2 051 775 A

(21) Application No **7922373**
(22) Date of filing **27 Jun 1979**
(43) Application published **21 Jan 1981**
(51) **INT CL[3]** **C03C 27/00**
(52) Domestic classification **C1M** 468 WF **H2E** EA
(56) Documents cited **None**
(58) Field of search **C1M** **H2E**

(71) Applicants
Welwyn Electric Limited,
Bedlington,
Northumberland,
NE22 7AA.
(72) Inventors
Ian Murray Connell

(54) **Bonding electrical components to thick film conductors**

(57) In a process for bonding and electrically connecting a first thick film electrical conductor on an electrical component or component part, such as a ceramic chip capacitor or resistor, to a second thick film electrical conductor on a support member, in which at least one of the first and/or second conductors consists of a dispersion of electrically conducting particles in a glass or glass-ceramic matrix, the component or component part is located on the supporting member such that the first conductor, or a composition adapted to produce it by heating is in contact with the second conductor or a composition adpated to produce it by heating. Heat is applied to cause fusion of the glass or glass-ceramic in at least one of the conductors or compositions and on cooling, the first conductor becomes bonded and electrically connected to the second conductor. The use of solder or other bonding agent is thus obviated.

SPECIFICATION

Process for bonding components to conductors

This invention relates to a process for bonding and electrically connecting one or more first thick film electrical conductors on an electricl component, or component part, to one or more corresponding second thick film electrical conductors on a supporting member. The invention is particularly, although not exclusively, applicable to components comprising ceramic chip capacitors or resistors.

In this specification, the expression 'thick film electrical conductor' is to be interpreted as meaning a dispersion of electrically conductive particles, e.g. one or more noble and/or base metal or metal alloy and/or metal oxide particles, in a glass or glass-ceramic matrix, or as meaning a glass fritless system in which electrically conductive particles are reactively bonded to a component or substrate. These thick film conductors are very well known in the art and are formed by applying to the component or substrate, by a process such as screen printing, a composition comprising, in the one case, electrically conductive particles and glass or glass-ceramic particles dispersed in a liquid vehicle (usually an organic liquid vehicle), and in the other case, electrically conductive particles together with particles of a reactive metal oxide, e.g. copper oxide, likewise dispersed in a liquid vehicle; and heating to a high temperature to drive off the vehicle and effect fusion of the glass or glass-ceramic, in the one case, and reactive bonding in the other case.

In the manufacture of thick film hybrid circuits, which generally comprise a pattern of thick film electrical conductors and, optionally, interconnected thick film electrical resistors on an electrically insulating substrate, usually of ceramic material, it is often required to bond and electrically connect components, such as ceramic chip capacitors or resistors, to the conductors on the substrate. Such components are frequently provided thereon with terminals in the form of thick film conductors instead of terminals in the form of lead wires. In order to bond and electrically connect the terminals on these components to thick film conductors on the circuit substrate the following processes have hitherto been adopted. In one process, a solder cream is applied to the conductors on the substrate in locations where the component is required to be connected. The component is then located with its terminals in contact with the solder cream and heat is applied to cause the solder to melt and flow and on cooling, the component becomes bonded and electrically connected to the conductors. This process is disadvantageous in that the solder tends to flow away from its initial location in an uncontrolled manner and may creep underneath the component and this may result is undesirable short-circuits occurring. Furthermore, the solder tends to leach the material of the conductors and this can cause problems with thin regions of the conductors which sometimes exist, resulting in some cases in complete loss of these regions of conductor. It sometimes also happens that with prolonged storage, tarnishing of the conductors on the components occurs with the result that the components become difficult to solder. One further disadvantage of this process is the need to include flux in the solder composition and this has a deleterious effect on other components in the hybrid circuit, particularly semiconductors. It is therefore generally necessary to remove all traces of soldering flux after effecting the bonding operation. This necessitates application of a solvent which may cause damage to sensitive components on the circuit and in any case may not adequately remove all traces of the soldering flux.

In another known process, an electrically conductive epoxy material comprising, for example, a dispersion of silver or gold powder in an epoxy resin, together with a hardener, is used to bond and electrically connect terminals on a component to conductors on a circuit substrate. Such a material tends to be difficult to control positionally after application and inconvenient to handle and furthermore, degradation of the hardened material occurs over a period of time resulting in cracking or crazing thereof. Outgassing can occur from the epoxy material, particularly when the circuit is subjected to elevated operating temperatures and the gaseous components released can be harmful to sensitive components on the circuit, especially in the case of semiconductor devices assembled on hermetically packaged circuits.

It is an object of the present invention to overcome or minimise the disadvantages of the above prior art processes.

The present invention provides a process for bonding and electrically connecting a first thick film electrical conductor on an electrical component or component part to a second thick film electrical conductor on a supporting member, at least one of said first and/or said second conductors comprising a dispersion of electrically conducting particles in a glass or glass-ceramic matrix, said process comprising locating said component or component part on said supporting member such that said first conductor, or a composition adapted to produce it by heating, is in contact with said second conductor, or a composition adapted to produce it by heating, and applying heat to cause fusion of said glass or glass-ceramic in at least one of said conductors or compositions whereby on cooling, said first conductor is bonded and electrically connected to said second conductor, said component or component part being one which is capable of withstanding the application of said heat without suffering damage.

Suitably said supporting member comprises a ceramic or glass-ceramic substrate.

Suitably said component or component part comprises a ceramic electrical capacitor or resistor.

During the said cooling it may be advantageous to effect a stabilisation treatment at a temperature of temperatures within the annealing range of said glass or glass-ceramic whereby any residual mechanical stresses in the resulting bonded assembly are minimised.

By means of the process of the invention, a component or component part provided with terminals in the form of thick film conductors is able to

be bonded and electrically connected, by means of these conductors, to thick film conductors on a substrate without the use of any additional intervening bonding agent, the conductors on the component or component part effectively becoming integrated with the conductors on the substrate.

The following example is given to illustrate the invention.

Ceramic chip capacitors of generally rectangular shape, each comprising a dielectric body based for example on titanate ceramic material and provided at opposite ends with a pair of first thick film conductor bands comprising a dispersion of palladium-silver particles in a glass matrix, are required to be bonded and electrically connected by the conductor bands to corresponding second thick film conductors on a supporting member in the/form of an electrically insulating substrate. Commercially available such capacitors are produced by Viclan Inc., of San Diego, California, U.S.A., types 1808, 1706 and 1505, of nominal value 2700 picofarads, being used for the present example.

A number of pairs of second thick film conductor tracks are provided on a substrate comprising 96% alumina, by screen printing Du Pont type 9308 palladium-silver and glass conductor composition onto the substrate, drying for about 10 minutes at room temperature followed by 15 minutes at 150°C and then heating at a peak temperature of 850°C for about 10 minutes. After cooling, the resulting pairs of second conductors comprise a dispersion of palladium-silver particles in a glass matrix. Each pair of conductors is provided in such a way that they are separated by a gap which can be bridged by a ceramic chip capacitor. The thickness of the second conductors, is increased at the adjacent ends of each pair by means of pads of Du Pont 9308 composition screen printed on top of the second conductors and allowed to dry for about 10 minutes at room temperature. Ceramic chip capacitors are located so as to bridge the gap between pairs of the second conductors and such that the first conductors on each chip contact the printed pads on corresponding second conductors. The resulting assembly is heated for about 15 minutes at 150°C, followed by heating at a peak temperature of 850°C for about 10 minutes. During this latter heat treatment, the glass in the conductor composition forming the pads on the second conductors fuses and on cooling, the first conductors on the capacitors become bonded and electrically connected to the second conductors. The capacitors are found to have changed in capacitance value by less than 0.05% during the bonding process. In a subsequent test to examine the electrical stability of the bonded capacitors, the substrate with the capacitors thereon is heated at 125°C for 2500 hours. The capacitance value if found to change by less than 0.03% during this test.

It is to be noted that the pads of conductor composition applied to the second conductors in the regions where the capacitors are to be bonded serve only to effectively increase the thickness of the second conductors to facilitate and improve the bonding process and effectively form part of the second conductors. They can be dispensed with sufficient thickness to enable satisfactory bonding to be subsequently achieved.

In the process of the invention the second conductors on the substrate, and the additional pads where provided, can be formed from the screen-printed composition by heating at the high temperature either before or after locating a capacitor in contact therewith. In the former case, subsequent heating at high temperature causes re-fusion of the glass in the first and/or second conductors to effect bonding whereas in the latter case the subsequent heating in addition to causing fusion of the glass in the composition for producing the second conductors and also possibly causing re-fusion of the glass in the first conductors, simultaneously effects formation of the second conductors.

Although in this example the first and second conductors both comprise a dispersion of electrically conductive (palladium-silver) particles in a glass matrix, it is only necessary that one of the conductors includes a glass matrix. The other conductor could comprise a glass-fritless thick film material in which electrically conductive material is reactively bonded directly to the substrate or component, such a material being very well known in the art.

It is surprising to a man skilled in the art to which this invention relates that the process of the invention works successfully. The coefficient of expansion with temperature of alumina ceramic materials used as substrates for thick film hybrid circuits may be markedly different from that of ceramic materials used for ceramic chip capcitors. It would be expected that on heating the substrate, with the capacitor located theron, to temperatures of the order of 850°C and then cooling to room temperature, the difference in expansion between the substrate and capacitor would result in considerable residual mechanical stress in the capacitor, bringing about a large change in the capacitance value of the capacitor during bonding and also subsequent instability of capacitance value. Surprisingly, no such large change in value or instability is experienced. However, as a precaution against any residual mechanical stresses resulting by the process, it may be advantageous at least in some instances to effect a stabilisation treatment, during cooling to room temperature, at a temperature within the annealing range of the glass or glass-ceramic material in the conductor or composition containing it.

CLAIMS

1. A process for bonding and electrically connecting a first thick film electrical conductor on an electrical component or component part to a second thick film electrical conductor on a supporting member, at least one of said first and/or said second conductors comprising a dispersion of electrically conducting particles in a glass or glass-ceramic matrix, said process comprising locating said component or component part on said supporting member such that said first conductor, or a composition adapted to produce it by heating, is in contact with said second conductor, or a composition adapted to produce it by heating, and applying heat to cause

fusion of said glass or glass-ceramic in a least one of said conductors or compositions whereby on cooling, said first conductor is bonded and electrically connected to said second conductor, said component or component part being one which is capable of withstanding the application of said heat without suffering damage.

2. A process according to Claim 1 in which said supporting member comprises a ceramic or glass-ceramic substrate.

3. A process according to Claim 1 or 2 in which said component or component part comprises a ceramic electrical capacitor or resistor.

4. A process for bonding and electrically connecting a first thick film electrical conductor to a second thick film electrical conductor substantially as herein described by way of example.

5. An assembly comprising a first thick film electrical conductor bonded to a second thick film electrical conductor whenever produced by the process of any one of Claims 1 to 4.

Printed for Her Majesty's Stationery Office by Croydon Printing Company Limited, Croydon Surrey, 1980.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.